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(71) Applicant *(for all designated States except US)*: **OCEAN SPRAY CRANBERRIES, INC.** [US/US]; One Ocean Drive, Lakeville-Middleboro, MA 02349 (US).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: **MANTIUS, Harold, L.** [US/US]; 117 Candlewood Drive, North Kingstown, RI 02852 (US).

(74) Agent: **MEIKLEJOHN, Anita, L.**; Fish & Richardson, P.C., 225 Franklin Street, Boston, MA 02110-2804 (US).

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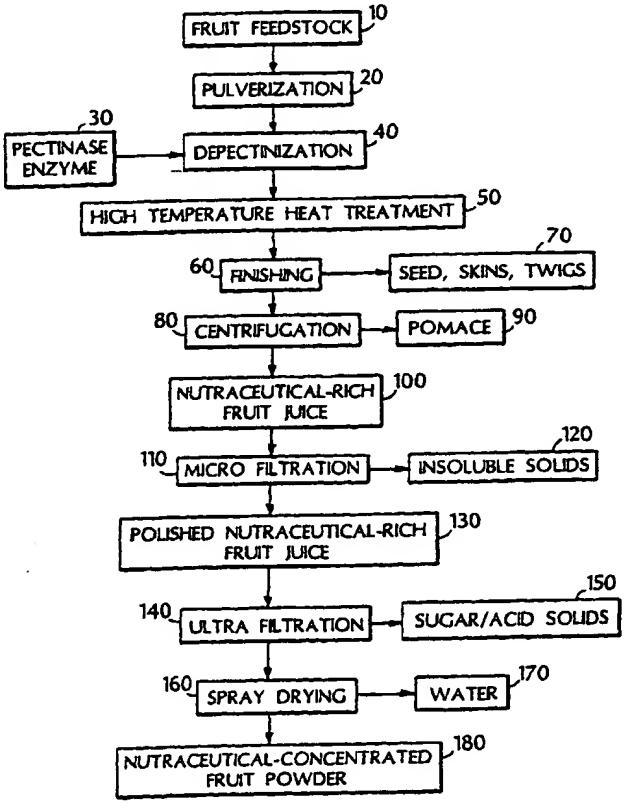
(54) Title: JUICE ENRICHED IN BENEFICIAL COMPOUNDS



(57) Abstract: A method is described for preparing, from various fruits and vegetables, including cranberries and other members of the genus *Vaccinium*, a juice that is relatively enriched for beneficial compounds. The method can be used to produce a juice, e.g., cranberry juice, enriched in beneficial health factors, e.g., factors which inhibit bacterial adhesion. Other beneficial health factors in fruits and vegetables, which are not fully recovered by conventional processing methods, may include, e.g., compounds that lower cholesterol, reduce the risk of various cancers, or reduce the risk of heart disease.

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JUICE ENRICHED IN BENEFICIAL COMPOUNDS

TECHNICAL FIELD

This invention relates to food processing, and more particularly to processing of fruits and vegetables.

BACKGROUND

Various fruits and vegetables are believed to contain a variety of compounds, often unidentified or poorly characterized, that are thought to confer health benefits. For example, cranberries contain a factor (most likely a specific class of proanthrocyanidins) that inhibits adhesion of certain types of bacteria to surfaces such as epithelial cells, and which confers a proven urinary tract health benefit. In addition to this anti-adhesion factor, cranberries may also contain other valuable factors that confer additional health benefits, such as compounds that lower cholesterol, reduce the risk of various cancers, or reduce the risk of heart disease. Thus, it would be beneficial to have available processing methods that result in fruit and vegetable products that retain high levels of beneficial compounds.

SUMMARY

A method is described for processing fruit or vegetables, e.g., cranberries, into a juice that is relatively enriched for beneficial compounds, e.g., factors which inhibit bacterial adhesion. The methods of the invention include controlled heat treatment of fruits or vegetables either before or after conventional processing steps used to produce juice. It is believed that a controlled heat treatment step will increase the yield of beneficial compounds in the juice produced from fruits or vegetables. The controlled heat treatment step entails heating the fruit or vegetables to greater than 140°F. Conventional fruit and vegetable processing techniques employed in the production of juice, e.g., liquification of fruit using pectinase enzymes prior to pressing or centrifugation, typically employ temperatures less than 140°F in order to minimize the deleterious effects of heat abuse, e.g., excessive browning or discolorization due to oxidative reactions, on the appearance and shelf life keeping qualities of the finished product. The controlled heat treatment step is carried out on a composition that includes fruits (or vegetables, or fruit presscake/pomace or fruit plant products or vegetable plant

products or some combination thereof) for a longer duration than the high temperature-short time (HTST) techniques characteristically used to deactivate enzymes naturally present in the composition. This is in contrast to methods in which juice (i.e., juice that is substantially free of insoluble solids) is heated to a relatively high temperature for pasteurization or some other purpose.

Fruit or vegetable juice that is enriched in beneficial compounds can be used for a variety of purposes. For example, juice that is enriched in an anti-adhesion factor can be used in juice drinks or as a food additive to confer anti-adhesion health benefits. In addition, the anti-adhesion factor enriched juice or juice fractions thereof can be used to coat materials to prevent adhesion of bacteria. For example, medical instruments, medical dressings, tampons and other sanitary products, diapers, and food processing equipment can be treated to reduce bacterial adhesion. In addition, the anti-adhesion factor enriched juice or juice fraction thereof can be added to toothpaste, mouthwash, antiseptics, and other topically administered products.

In one embodiment, the invention features, a method for processing fruits which includes: (a) providing a composition comprising fruit (e.g., whole fruit and/or fruit that has been processed to size-reduce whole fruit and/or frozen fruit and/or extracted fruit) of at least one species; (b) heating the fruit composition to greater than 140°F for at least 2 minutes to generate a heat-treated fruit composition; (c) treating the heat-treated fruit composition to substantially separate fruit juice from the insoluble fruit solids (e.g., seeds, skins, pulp, and the like) present in the composition; and (d) collecting the fruit juice. In another embodiment, the method further includes exposing the heat-treated fruit composition to pectinase enzyme prior to the separation step. In other embodiments, the method includes: exposing the fruit composition to pectinase enzyme prior to the heating step; concentrating the fruit juice; microfiltering the fruit juice to provide a microfiltered fruit juice; and ultrafiltering the microfiltered fruit juice to provide an ultrafiltered fruit juice fraction; and drying the fruit juice or juice fraction thereof to produce a powder. In other embodiments, the heating step comprises heating the fruit composition to greater than 150°F, greater than 160°F, greater than 170°F, greater than 180°F, greater than 190°F, heating the fruit composition for at least 4 minutes heating; the fruit composition for at least 5 minutes; heating the fruit composition to greater than 140°F for at least 10 minutes; and heating the fruit composition to greater than 140°F for at least 15 minutes.

The invention also features a method for processing fruit presscake/pomace comprising: (a) providing a composition comprising fruit presscake/pomance of at least one species of fruit; (b) heating the fruit presscake/pomace composition to greater than 170°F to generate a heat-treated fruit presscake/pomance composition; (c) treating the heat-treated fruit presscake/pomace composition to substantially separate fruit presscake/pomace juice from fruit presscake/pomace insoluble solids present in the composition; and (d) collecting the fruit presscake/pomace juice. The invention also features a method for processing fruit plant component comprising: (a) providing a fruit plant composition comprising leaves or stems of at least one species of fruit plant; (b) heating the fruit plant composition to greater than 140°F to generate a heat-treated fruit plant composition; (c) treating the heat-treated fruit plant composition to substantially separate fruit plant liquid from fruit plant insoluble solids present in the composition; and (d) collecting the fruit plant juice.

In another embodiment, the invention features a method for processing vegetables comprising: (a) providing a vegetable composition comprising at least one species of vegetable; (b) heating the vegetable composition to greater than 140°F for at least 2 minutes to generate a heat-treated vegetable composition; (c) treating the heat-treated vegetable composition to substantially separate vegetable juice from the insoluble vegetable solids present in the composition; and (d) collecting the vegetable juice.

In yet another embodiment, the invention features a method for processing fruits and vegetables comprising: (a) providing a fruit and vegetable composition comprising at least one species of vegetable and at least one species of fruit; (b) heating the fruit and vegetable composition to greater than 140°F to generate a heat-treated fruit and vegetable composition; (c) treating the heat-treated fruit and vegetable composition to substantially separate vegetable juice from the insoluble fruit and vegetable solids present in the composition; and (d) collecting the fruit and vegetable juice.

The invention also features juices produced by the methods of the invention, as well as foods, beverages, nutritional, and therapeutic products comprising such juices.

The methods of the invention can be used to process any desired fruit or vegetable or combination thereof, other than tomatoes, for example, cranberries, blueberries, bilberries, blackberries, currants, raspberries, strawberries, cherries, grapes, apples, peaches, pears, mangos, kiwis, guavas, oranges, grapefruits, lemons, limes,

prunes, lingonberries, melons, apricots, and nectarines, carrots, celery, lettuce, wheatgrass, kale, broccoli, beans, cauliflower, cucumbers, squash, turnips, potatoes, yams, and beets.

The details of one or more embodiments of the invention are set forth in the accompanying drawing and the description below. Other features, objects, and advantages of the invention will be apparent from the description and drawing, and from the claims.

DESCRIPTION OF DRAWINGS

The FIGURE is a flow diagram of a process for production of a nutraceutical rich fruit juice.

DETAILED DESCRIPTION

Referring to the Figure, a flow diagram is shown of a process for preparing fruit or vegetable juice that is rich in beneficial components. The process can begin with any fruit or vegetable feedstock, e.g., fruit of the genus *Vaccinium*. In the embodiment of the Figure, fruit feedstock from a fruit feedstock supply 10 is conveyed to optional pulverization stage 20 where it is pulverized (e.g., using a Urshel, Inc. Comitrol Processor Model 1700), sliced, diced, chopped, ground, or treated in some other manner to reduce the fruit to a size suitable for efficient depectinization. The pulverized material is conveyed to a depectinization stage 40 where it is treated with pectinase enzyme provided by a pectinase enzyme supply 30 under sufficient conditions of time and temperature (e.g., about 4 hours at 110° F-120° F) to enable effective depectinization of the fruit mash and thereby to afford good physical separation of the resulting solid and liquid phases. The pectinase-treated mash is passed to a controlled high temperature heat treatment stage 50 where it is heated to about 180°F to further release water soluble compounds (e.g., phenolics, proanthocyanidins, and anthocyanins) bound to the solid phase (pulp, skin, and seeds). In general, the heat treatment is greater than 140°F (e.g., at least 150° F, 160° F, 170° F, 180° F, 190° F, 200° F, 210°F, or 212 ° F) and is carried out for a longer duration than the high temperature-short time (HTST) techniques that are characteristically used to deactivate enzymes naturally present in the fruit. Thus, the heat treatment preferably lasts for at least 2 minutes, at least 3 minutes, at least 5 minutes or even at least 10-15 minutes or even longer (e.g., at least 20 minutes,

30 minutes, or even 1 hour). The heat treatment can occur before or after depectinization, and depectinization is itself optional. For example, certain fruits, e.g., strawberries, may not need to be depectinized to afford good physical separation of the solid and liquid phases of the fruit mash resulting from heat treatment.

The heat treated material is next conveyed to a finishing stage 60 where it is passed through a continuous screening device (e.g., a Langsenkemp, Inc. continuous screening device with 0.033 inch openings) or otherwise treated to remove seeds, skins, twigs and the like which are passed to a seeds, skins, and twigs collector 70. The finished material is next conveyed to a centrifugation stage 80 where a centrifuge (e.g., Westphalia, Inc. Model CA505) or other device, e.g., a press, is used to remove suspended solids as a fiber rich pomace that is conveyed to a pomace collector 90. This finishing stage is optional, but is useful for generating clean pomace. If finishing stage 60 is omitted, the seed, skins, twigs and other material that would be collected at 70 are instead passed to the pomace collector 90.

After centrifugation stage 80, a fruit juice 100 rich in beneficial (or nutraceutical or phytochemical) compounds--compared to that normally obtained by conventional juice processing methods--is obtained. For example, in the case of cranberries, the juice is enriched for anti-adhesion factor.

The nutraceutical rich fruit juice 100 can be further treated as follows. The juice is passed to a microfiltration stage 110 were it is microfiltered (e.g., using a Koch Membrane Systems, Inc. skid with a Koch Membrane Systems, Inc. model MFK617 membrane or other system with comparable pore size attributes) or effectively processed using some other separation technology to remove residual insoluble solids which are passed to an insoluble solids collector 120. This polished nutraceutical rich fruit juice 130 can be used as discussed above or it can be further processed. Thus, the polished juice can be passed to an ultrafiltration stage 140 were it is ultrafiltered (e.g., using a Koch Membrane Systems, Inc. skid with a Osmotics Desal, Inc. model GK3840C membrane) or processed using some other separation technology to remove lower molecular weight sugar and acid solids. The sugar and acid solids are passed to a sugar and acid solids collector 150.

Ultrafiltration stage 140 can be replaced by a fermentation step. Under these circumstances, the alcohol created by fermentation can be subsequently removed by evaporation. This will yield a nutraceutical rich fruit juice product substantially reduced

in sugar, but still containing its natural complement of acids. Such a product may be particularly useful as a source of beneficial compounds where the natural acidity of the juice product is also considered a desirable attribute.

Finally, the ultrafiltered material can be spray dried (e.g., using a NIRO, Inc. spray drier with a F35 atomizer) to remove water 170 and produce a nutraceutical rich fruit powder 180.

The forgoing is a description of one embodiment of the method of the invention. Those skilled in the art will be able to modify the process. For example, controlled atmosphere (e.g., N_2 or CO_2) techniques can be used during the depectinization and heat treatment stages to minimize the deleterious effects of oxidative reactions.

In another modification enzymes in addition to or instead of pectinase (e.g., enzymes which digest cellulose) can be used at the depectinization stage.

Extracted fruit produced by water extraction, e.g., countercurrent extraction, as described in U.S. Patent 5,320,861, hereby incorporated by reference, or the press cake/pomace discharge of conventional fruit processing techniques used in the production of fruit juice can be used as the fruit feedstock. Moreover, instead of using whole fruit as a feedstock, leaves and other components of the fruit plant can be used. Alternatively the fruit plant components can be used as a feedstock in combination with whole fruit.

Countercurrent extracted cranberries can be used as a fruit feedstock in the methods of the invention as follows. Frozen whole raw cranberries are provided to a cleaning stage to remove debris such as twigs, leaves, etc. and then conveyed to a sorting stage which sorts fruit to a selected size. The size-selected fruit is then conveyed a slicing stage which slices the berries to expose the inner flesh of the fruit, unprotected by the skin. The whole cranberries are preferably cut to provide slices between 6 to 8 millimeters in width.

The cleaned, sized and sliced frozen cranberries are then defrosted using hot water (e.g., at about 130°F) to a temperature of less than 75°F (e.g., 65°F) and conveyed to the solid input of an extractor stage which employs a countercurrent extractor described in detail in U.S. Patent No. 5,320,861. The liquid input to the extractor is typically fruit-derived water from a fruit-derived water supply. The liquid output of the extractor stage is a high-quality extract mixture of fruit-derived water and fruit juice, which is collected for further treatment and use. Decharacterized (extracted) cranberry

pieces, exiting as the solid output of the extraction stage can be used as a feedstock in the methods of the invention. Under these circumstances, pulverization stage 20 shown in the Figure can often be eliminated.

In a study to measure the effect of a controlled heat treatment step on the level of beneficial compounds in the resulting fruit juice, pectinase enzyme-treated, extracted cranberries were either not subjected to a controlled heat treatment step or were heated to 170°F, 190°F, or 210°F for 15 minutes, and subsequently further processed to produce juice. The percent yield of proanthrocyanidins in the juice then was measured relative to the incoming level of proanthrocyanidins in the extracted cranberries. In the absence of a controlled heat treatment step, proanthrocyanidin yield was about 40.2%. After 170°F treatment, the proanthrocyanidin yield was about 56.4%. After 190°F treatment, proanthrocyanidin yield was about 70.7%. After 210°F treatment, the proanthrocyanidin yield was about 65.0%. This study demonstrates that a controlled heat treatment step can be used to produce a juice enriched in beneficial compounds.

A number of embodiments of the invention have been described. Nevertheless, it will be understood that various modifications may be made without departing from the spirit and scope of the invention. Accordingly, other embodiments are within the scope of the following claims.

WHAT IS CLAIMED IS:

1. A method for processing fruits comprising:
   (a) providing a composition comprising fruit of at least one species;
   (b) heating the fruit composition to greater than 140°F for at least 2 minutes to generate a heat-treated fruit composition;
   (c) treating the heat-treated fruit composition to substantially separate fruit juice from insoluble fruit solids present in the composition; and
   (d) collecting the fruit juice.

2. The method of claim 1 further comprising exposing the heat-treated fruit composition to pectinase enzyme prior to step (c).

3. The method of claim 1 wherein the fruit composition comprises fruit that has been processed to size-reduce whole fruit.

4. The method of claim 1 further comprising exposing the fruit composition to pectinase enzyme prior to the heating step.

5. The method of claim 1 wherein the fruit composition comprises frozen fruit.

6. The method of claim 1 further comprising concentrating the fruit juice.

7. The method of claim 1 further comprising drying the fruit juice to produce a powder.

8. The method of claim 1 further comprising microfiltering the fruit juice to provide a microfiltered fruit juice.

9. The method of claim 8 further comprising ultrafiltering the microfiltered fruit juice to provide an ultrafiltered fruit juice fraction.

10. The method of claim 1 wherein the heating step comprises heating the fruit composition to greater than 150°F.

11. The method of claim 10 wherein the heating step comprises heating the fruit composition to greater than 160°F.

12. The method of claim 11 wherein the heating step comprises heating the fruit composition to greater than 170°F.

13. The method of claim 12 wherein the heating step comprises heating the fruit composition to greater than 180°F.

14. The method of claim 13 wherein the heating step comprises heating the fruit composition to greater than 190°F.

15. The method of claim 1 wherein the heating step comprises heating the fruit composition to greater than 140°F for at least 4 minutes.

16. The method of claim 15 wherein the heating step comprises heating the fruit composition to greater than 140°F for at least 5 minutes.

17. The method of claim 16 wherein the heating step comprises heating the fruit composition to greater than 140°F for at least 10 minutes.

18. The method of claim 17 wherein the heating step comprises heating the fruit composition to greater than 140°F for at least 15 minutes.

19. The method of claim 1 wherein the fruit composition comprises extracted fruit.

20. The method of claim 1 wherein the fruit composition comprises fruit of the genus *Vaccinium*.

21. The method of claim 20 wherein the fruit composition comprises cranberries.

22. A method for processing fruit presscake/pomace comprising:

(a) providing a composition comprising fruit presscake/pomace of at least one species of fruit;

(b) heating the fruit presscake/pomance composition to greater than 170°F to generate a heat-treated fruit presscake/pomace composition;

(c) treating the heat-treated fruit presscake/pomance composition to substantially separate fruit presscake/pomace juice from fruit presscake/pomace insoluble solids present in the composition; and

(d) collecting the fruit presscake/pomace juice

23. A method for processing fruit plant component comprising:

(a) providing a fruit plant composition comprising leaves or stems of at least one species of fruit plant;

(b) heating the fruit plant composition to greater than 140°F to generate a heat-treated fruit plant composition;

(c) treating the heat-treated fruit plant composition to substantially separate fruit plant liquid from fruit plant insoluble solids present in the composition; and

(d) collecting the fruit plant juice.

24. A method for processing vegetables comprising:

(a) providing a vegetable composition comprising at least one species of vegetable;

(b) heating the vegetable composition to greater than 140°F for at least 2 minutes to generate a heat-treated vegetable composition;

(c) treating the heat-treated vegetable composition to substantially separate vegetable juice from insoluble vegetable solids present in the composition; and

(d) collecting the vegetable juice

25. A method for processing fruits and vegetables comprising:

(a) providing a fruit and vegetable composition comprising at least one species of vegetable and at least one species of fruit;

(b) heating the fruit and vegetable composition to greater than 140°F to generate a heat-treated fruit and vegetable composition;

(c) treating the heat-treated fruit and vegetable composition to substantially separate vegetable juice from insoluble fruit and vegetable solids present in the composition; and

(d) collecting the fruit and vegetable juice.

26. The method of claim 24 further comprising concentrating the vegetable juice.

27. The method of claim 24 further comprising drying the vegetable juice to produce a powder.

28. The method of claim 24 further comprising microfiltering the vegetable juice to provide a microfiltered vegetable juice.

29. The method of claim 24 further comprising ultrafiltering the microfiltered vegetable juice to provide an ultrafiltered vegetable juice fraction.

30. The method of claim 24 wherein the heating step comprises heating the vegetable composition to greater than 150°F.

31. The method of claim 30 wherein the heating step comprises heating the vegetable composition to greater than 160°F.

32. The method of claim 31 wherein the heating step comprises heating the vegetable composition to greater than 170°F.

33. The method of claim 32 wherein the heating step comprises heating the vegetable composition to greater than 180°F.

34. The method of claim 33 wherein the heating step comprises heating the vegetable composition to greater than 190°F.

35. The method of claim 24 wherein the heating step comprises heating the vegetable composition to greater than 140°F for at least 4 minutes.

36. The method of claim 35 wherein the heating step comprises heating the vegetable composition to greater than 140°F for at least 5 minutes.

37. The method of claim 36 wherein the heating step comprises heating the vegetable composition to greater than 140°F for at least 10 minutes.

38. The method of claim 37 wherein the heating step comprises heating the vegetable composition to greater than 140°F for at least 15 minutes.

39. The method of claim 24 further comprising exposing the vegetable composition or the heat treated vegetable composition to an enzyme.

40. The method of claim 24 wherein the vegetable composition comprises vegetables that have been processed to size-reduce whole vegetables.

41. The method of claim 24 wherein the vegetable composition comprises frozen vegetables.

42. The method of claim 8 further comprising drying the microfiltered fruit juice to produce a powder.

43. The method of claim 9 further comprising drying the ultrafiltered fruit juice fraction to produce a powder.

44. The method of claim 28 further comprising drying the microfiltered vegetable juice to produce a powder.

45. The method of claim 29 further comprising drying the ultrafiltered vegetable juice fraction to produce a powder

46. A fruit juice prepared by the method of claim1

47. A vegetable juice prepared by the method of claim 24.

48. A fruit and vegetable juice prepared by the method of claim 25.

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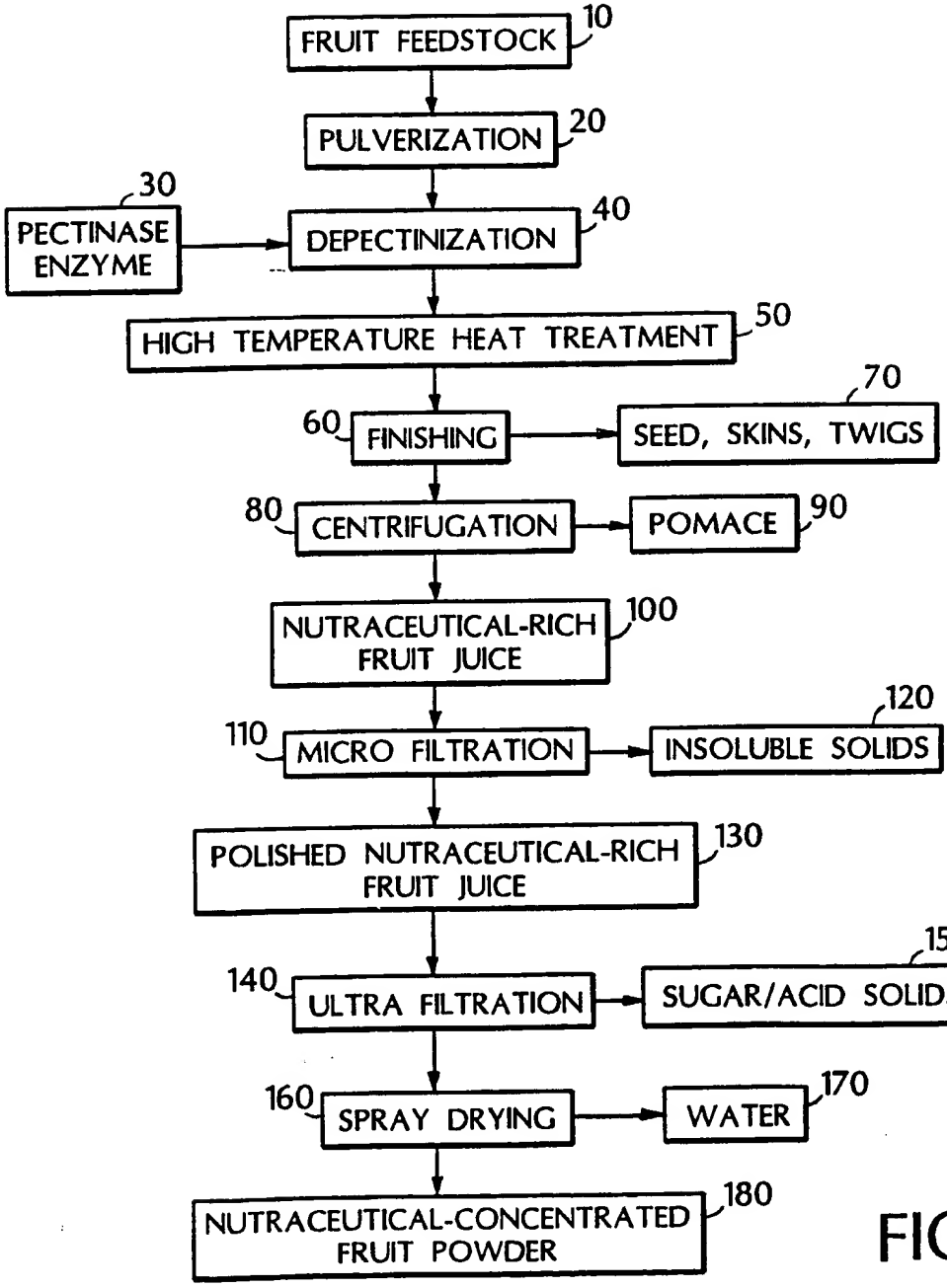
FRUIT FEEDSTOCK
10
PULVERIZATION
20
PECTINASE ENZYME
30
DEPECTINIZATION
40
HIGH TEMPERATURE HEAT TREATMENT
50
60
FINISHING
SEED, SKINS, TWIGS
70
80
CENTRIFUGATION
POMACE
90
NUTRACEUTICAL-RICH FRUIT JUICE
100
110
MICRO FILTRATION
INSOLUBLE SOLIDS
120
POLISHED NUTRACEUTICAL-RICH FRUIT JUICE
130
140
ULTRA FILTRATION
SUGAR/ACID SOLIDS
150
160
SPRAY DRYING
WATER
170
NUTRACEUTICAL-CONCENTRATED FRUIT POWDER
180

FIG. 1

INTERNATIONAL SEARCH REPORT

Interna al Application No
PCT/US 00/18436

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A23L3/16 A23L2/02 A23L2/74 A23L2/04 A23L1/30

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A23L A23B A61K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ, FSTA, BIOSIS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 004, no. 098 (C-018), 15 July 1980 (1980-07-15) & JP 55 061778 A (HARAMAKI YOSHITO), 9 May 1980 (1980-05-09) abstract --- -/--	1,10-18, 22-25, 30-38, 46-48

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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Date of the actual completion of the international search	Date of mailing of the international search report
27 October 2000	06/11/2000

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

Internal Application No
PCT/US 00/18436

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	FR 2 296 012 A (CANTARELLI CORRADO) 23 July 1976 (1976-07-23) claims 1-9 page 2, line 1 - line 9 page 5, line 28 -page 6, line 14 page 6, line 35 -page 7, line 6	1-6,8, 10-12, 15-20, 22-26, 28, 30-32, 35-41, 46-48
X	US 3 818 110 A (DESSOLIN D ET AL) 18 June 1974 (1974-06-18) column 2, line 28 - line 57; claims 1-4	1-4,6-8, 10,11, 15-18, 23-28, 30,31, 35-40, 42,44, 46-48
X	US 4 330 565 A (HAMADA AKIKO) 18 May 1982 (1982-05-18) column 3, line 21 - line 53; claims 1,3-5,7; figure 1	1,6,8, 10-18, 22-26, 28, 30-38, 40,46-48
X	PATENT ABSTRACTS OF JAPAN vol. 014, no. 254 (C-0724), 31 May 1990 (1990-05-31) & JP 02 072850 A (EHIME PREF GOV SEIKA NOGYO KYODO KUMIAI RENGOKAI), 13 March 1990 (1990-03-13) abstract	1,3,6,8, 10-12, 19, 22-26, 28, 30-32, 40,46-48
X	US 3 666 487 A (TAMOTSU YOKOTSUKA ET AL.) 30 May 1972 (1972-05-30) claim 1 column 3, line 24 - line 27 column 3, line 33 - line 48; example 3 column 6, line 8 -/--	1-4,6, 10,11, 15-17, 19, 23-26, 30,31, 35-37, 39,40, 46-48

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INTERNATIONAL SEARCH REPORT

Interna' al Application No
PCT/US 00/18436

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	WO 98 24331 A (BARTH FRUIT AG) 11 June 1998 (1998-06-11)	46-48
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